Increasing quantity of parental talk to two-year-olds through intervention: Effects on quality of interaction and facilitative language

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Abstract

Researchers have found that parents in low-income families tend to speak less to their children than parents in middle- and high-income families. The cumulative effects of this disparity result in a higher prevalence of language and academic difficulties among children from low-income families. This study extended an existing project at The Ohio State University, Project RETOLD, which aimed to design an intervention to increase the quantity of parental talk to two-year-olds in low-income families. A recording device and automated analyses estimated the quantity of language in number of adult words spoken per day as well as number of conversational turns between adult and child. The intervention sought to bring families up to the 50th percentile in both categories. While this intervention was successful, it remained unclear whether the quality of interaction or the amount of facilitative language improved along with the quantity. To investigate this question, samples of parental speech at baseline and after intervention were transcribed to determine whether changes in the quantity of language were associated with changes in the quality of talk and the use of facilitative language. Many indicators of the quality of language were measured, including types of questions and feedback, conversation initiations and responses, and vocabulary diversity. A significant improvement in quality overall was noted, although this improvement may be due to the success of only two variables; raw numbers still remained low and changes did not represent the well-rounded improvements hypothesized. This intervention has seen some obvious success, however, these results have implications for investigating modifications in intervention procedures to promote more facilitative language overall.

Increasing Quantity of Parental Talk to Two-Year Olds Through Intervention: Effects on Quality of Interaction and Facilitative Language

Differences in academic achievement by economic class have long been the subject of scrutiny. In general, students from working class and high poverty families are more likely to have depressed academic skill sets and struggle more in school compared to children from middle- and upper-class families (Kieffer, 2010; Walker, Greenwood, Hart, & Carta, 1994; Weizman & Snow, 2001) as well as score lower on intelligence tests administered after age three (Ducan, Brooks-Gunn, & Klebanov, 1994; Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009; McDonald, Signman, & Ungerer, 1989). For decades these differences were simply assumed to be the result of children's innate intelligence or aptitude. However, evidence gathered in recent years strongly suggests that these immense academic gaps are largely independent of individual intelligence and are strongly correlated with early language development. Children in low socioeconomic status (SES) homes are exposed to different language experiences than children from higher income families (Greenwood, Thiemann-Bourque, Walker, Buzhardt, & Gilkerson, 2011; Hart & Risley, 1995; Hoff, 2003; Hoff & Tian, 2005; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2001; Walker et al., 1994; Weisman & Snow, 2001). The differences are profound and contribute to the development of below-average language skills in low SES children compared to their higher SES peers, which in turn contributes to the differences in academic achievement by economic class (Aram, 2005; Ducan, Brooks-Funn, & Klebanov, 1994; Feitelson et al., 1993; McDonald, Sigman, & Ungerer, 1989; Scarborough, 2009; Walker, Greenwood, Hart, & Carta, 1994; Weisman & Snow, 2001). Researchers have thus begun to regard socioeconomic class as a strong predictor of early language development and later academic success, and the development of intervention strategies to bridge the academic

achievement gap have been focused on ensuring that early language experiences are sufficient in promoting adequate language development.

Language Input Differences by SES

Hart and Risley (1995) began research in the 1980s which culminated in the determination that language input heard by young children differed by socioeconomic status in terms of vocabulary diversity, length of utterance, sentence structure, sentence complexity, language function, and conversation style, among others facets. The most notable difference between parental talk by economic class was found to be the number of words spoken to children. In their study of 42 children from professional (n=13), working class (n=23), and welfare (n=6) homes, professional parents averaged 2,100 words spoken to their child per hour, working class parents averaged 1,200 words, and welfare parents averaged 600 words per hour (Hart & Risley, 1999). Even more astonishing is the average cumulative words addressed to children in each class by age 3: studied over two and a half years since 6 months of age, the project's children from professional families heard around 35 million words by age 3, working class children just over 20 million, and welfare children just over 10 million (Hart & Risley, 1995). These results showed that children from professional homes heard about three times more words per hour and three-and-a-half times more words by age 3 than children from families on welfare. At the end of the study the working-class and welfare-dependent children had below-average vocabularies and language skills, which Hart and Risley (1995) attributed to the diminished amount of rich language experiences compared to higher income peers.

Since Hart & Risley's pioneering study, other researchers have investigated different aspects of parental linguistic input and child language skill outcome and obtained congruent findings. Aspects of maternal language "richness"—such as number of utterances, number of words, diversity of vocabulary, and mean length of utterance in morphemes—have been

measured in an attempt to replicate Hart and Risley's findings, and as predicted were all observed at lower rates as household socioeconomic status decreased (Greenwood, Thiemann-Bourque, Walker, Buzhardt, & Gilkerson, 2011; Hart & Risley, 1992; Hoff, 2003; Hoff & Tian, 2005; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2001; Walker et al., 1994; Weisman & Snow, 2001). Maternal education, the most significant component of SES aside from extreme poverty shown to influence differences in parenting (Hoff, 2003), is also of interest. Dollaghan et al. (1999) found linear trends between the amount of schooling obtained and parental total number of words, number of different words, mean length of utterances in morphemes, and scores on the Peabody Picture Vocabulary Test. Hoff-Ginsberg (1991) found differences between classes in regards to language richness, where increased vocabulary diversity and high rates of expansions on child utterances were shown to promote child language development by encouraging further conversation and understanding; working-class mothers showed a less diverse vocabulary and a lower percent of expansions, meaning their input was less likely to contribute to language development. Rush (1999) also found lower rates of expansions of child vocalizations, as well as lower rates of feedback or acknowledgment of child language in general, in lower SES homes.

Early Language Input and Development of Language and Other Skills

Once these differences in parental input by economic class were established, researchers also found the differences to be predictive of language, cognitive, and literacy development. Rush (1999), Dollaghan et al. (1999), and Hoff (2003) all found that, even after controlling for cognitive ability and level of language development at the start of observation, SES and its associated differences in language input proved to be strong predictors of child language growth and outcome. For example, Hoff and Naigles (2002) found a strong correlation between parental number of distinct words and mean length of utterance and subsequent child lexical growth.

Rush (1999) reported parental rates of positive feedback and requests for language to be moderately correlated with child language measures, and language input differences by SES to be highly correlated with early literacy skills such as letter naming, phonological awareness, and expressive and receptive vocabulary skills. Maternal vocabulary diversity also has been shown to be predictive of children's rate of vocabulary growth and overall vocabulary level outcome (Hoff, 2003). Dollaghan et al. (1999) found that nearly one-third of the participants whose mothers had obtained lower levels of education scored 1.5 or more standard deviations below national averages of language measures. Other researchers using maternal education level as a measure of language input have found similar results (Huttenlocker et al., 2007).

As seen in the aforementioned studies, language input differences by economic class often result in children from lower SES families developing language at a delayed or insufficient rate compared to their higher SES peers. Other researchers have further demonstrated that this lack of language skills permeates nearly every aspect of education and causes academic struggles up to ten years after starting school. McDonald, Sigman, and Ungerer (1989) found language skills in children of both 13.5 months and 22 months of age to be strong predictors of cognitive and behavioral outcomes at age five when traditional schooling begins. Out of all measures used at these young ages, including sensorimotor, free play, developmental, behavioral, and intelligence quotient (IQ) assessments, language measures were by far the most predictive of cognitive outcomes. The implications of this study are that cognitive and behavioral abilities at the start of traditional schooling are predictive of later academic achievement. Walker, Greenwood, Hart, and Carta (1994) corroborated these findings with a five-year follow-up study of the Hart and Risley cohort. Results indicated that the number of distinct words and mean length of utterance in morphemes at age 3 was significantly correlated with receptive language skills and verbal ability measures in kindergarten. When the effects of SES and early language

skills were combined, they became significant predictors of abilities in receptive language and spoken language, as well as academic achievement measures (i.e., spelling, reading achievement, and verbal ability) through third grade, when the study concluded. Additionally, Weisman and Snow (2001) report early vocabulary development to be linked to participation in book reading, a social interactional routine that facilitates the learning of new words. They cite work stating that book reading is important to success in the classroom, where conversations often focus on the meaning of stories from books and foster vocabulary learning (Feitelson et al., 1993).

Interventions and This Study

Historically, schools have established intervention programs as early as preschool or kindergarten to try to overcome the pattern of lower academic achievement in low-SES children with below-average language skills. However, Hart and Risley (1995) have shown that even age 3 or 4 is too late to begin intervention. This is supported by other researchers; studies indicate that language skills at age 3 are very predictive of later academic success and therefore that the linguistic input that occurs before this critical age should be the target of intervention (McDonald, Sigman, and Ungerer, 1989; Walker, Greenwood, Hart, and Carta, 1994). Rush (1999) echoed Hart and Risley by pointing out that differences in language skill level by economic class are evident as early as preschool, before children enter the formal education system where traditional language intervention begins, making it incredibly difficult for students with depressed skill sets to catch up to their average and above-average peers. Researchers are therefore calling for new interventions beginning in infancy or toddlerhood that help parents in high poverty homes provide sufficient linguistic experiences to their children (Hart & Risley, 1995; Hart & Risley, 1999).

The RETOLD (Research to Enhance the Trajectory of Language Development) Project, initiated at The Ohio State University in June 2011, is answering this call to action and has the

long-term goal of reducing preventable developmental delays by investigating parent-child interactions and linguistic input in high poverty homes. Because Hart and Risley (1992, 1995, 1998) and other researchers report a large discrepancy between economic classes in the sheer number of words a child is exposed to at home and show these differences to be predictive of later language and academic skills (Greenwood, Thiemann-Bourque, Walker, Buzhardt, & Gilkerson, 2011; Hoff, 2003; Hoff & Naigles, 2002; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2001; Walker, Greenwood, Hart, & Carta, 1994; Weisman & Snow, 2001), RETOLD researchers developed a parental intervention designed to increase the quantity of interactions and linguistic input of low-SES parents with their two-year-olds. Specifically, researchers aim to increase these families from about the 20th to the 50th percentile in number of words spoken to their children and in number of conversational turns between parent and child. The goal is that these children who are at risk of language delays will gain timely access to the linguistic input necessary for later success in learning to read and performing well in school.

RETOLD is using LENA (Language Environment Analysis System), an acoustic analysis technology that has been used by other researchers to study linguistic input (Greenwood et al., 2011), to collect data in high poverty homes in the Columbus area. The unobtrusive LENA device records everything within about a six-foot radius of the child wearing it. For this study, LENA was meant to be worn all day for three days each week to get a representative sample of the home language environment. The LENA software analyzes the recordings in a number of different ways, including estimating how much of a child's linguistic input consists of adult speech and how many interactions children have with their adult caregivers (measured in conversation turns between parent and child).

A limitation of LENA, however, is that while it records all linguistic input it does not transcribe speech. This means that many other facets of language input shown to be important to

early language development and later academic skills—such as vocabulary diversity, expansions and extensions of child utterances, the use of affirmative versus prohibitive statements, positive versus negative feedback tones, guidance style, responsiveness, and question types, to name a few (Hart & Risley, 1992; Hart & Risley, 1995; Hoff, 2003; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2001; Walker, Greenwood, Hart, & Carta, 1994; Weisman & Snow, 2001)—cannot be evaluated by LENA. Thus, one of this study's goals was to address areas of parents' language that LENA cannot. LENA language samples were transcribed and the amount of facilitative language was quantified to assess the likelihood of parents' speech promoting their child's language skills. As Hart & Risley (1995) have found, richness of parental language typically increases as the number of words increases. Therefore, this study hypothesized that as the RETOLD intervention is introduced to each family an increase in the quantity of language would be accompanied by an increase in the amount and proportion of facilitative language. If supported, it would appear that the intervention is affecting language input in ways that make it more similar to that of higher SES homes, thereby increasing children's chances of entering formal schooling with language skills similar to their higher SES peers. To explore this hypothesis, results from one family from the RETOLD participants were examined to determine if improvements in the quantity of language also improved the quality of talk and the amount of facilitative language.

Method

Participants

Participants of the RETOLD study consisted of 6 parents in 5 different households in the Columbus area, 4 of which were headed by single mothers and 1 by a married couple. To qualify for RETOLD, heads of households must have had a 24 to 36-month-old child and be eligible for subsidized housing. Out of the 5 households who qualified and recorded baseline

data, 3 continued through the intervention phase and 2 through the maintenance phase. One family did not continue because baseline observations were too high (around the 50th percentile) to warrant intervention. The household with the greatest increase in the number of adult words and conversational turns (as recorded by LENA) following the intervention was chosen for this case study. This family consisted of a married African American couple and their 24-month-old son, as well as three older children who were not directly participating. The father had a high school diploma and the mother had a high school diploma and was in the process of obtaining a post-baccalaureate degree in nursing. African American English was the dialect most often spoken by all members of the household. LENA analyses of baseline data indicated a mean of 8,080 adult words per day (22nd percentile) and 313 conversational turns per day (20th percentile) (see Table 1).

Materials

The main tool used in the RETOLD interventions and in this study was LENA (Language Environment Analysis System) technology. A DLP (Digital Language Processor) records the audio environment and is a small device that fits into a special pouch on a shirt worn by the child. The LENA software is then able to analyze this audio input to derive estimates of what the child hears and says. Quantifiable outputs for which there are norms include adult words, child vocalizations, and conversational turns between adult and child. Amount of television/radio input along with other background noise is also measured.

For data analysis, a custom computer program was created to count the number of adult words and conversational turns of each day's transcript (code available in Appendix A, Figure A3). SALT (Systematic Analysis of Language Transcripts) software was used to determine number of word types and tokens and the type/token ratios. All other categorical analyses were done by hand using Microsoft Excel (see Table A2 for examples).

Intervention Procedures

The RETOLD intervention was designed with a general focus. Rather than outlining specific procedures, it operated with the goal of helping parents, with the guidance of the therapist, identify their own strategies to increase the number and length of interactions. A single researcher (the "therapist") on the team conducted intervention and feedback/follow-up sessions. Both parents were present at the initial intervention session, and if one parent was absent at a later follow-up meeting, notes were taken and passed along to and read by the absent parent.

Based on hourly LENA outputs, the therapist helped the participants choose an hourly routine (e.g., lunchtime, getting ready in the morning) during which they would focus on increasing child-directed language. The therapist then briefly modeled activities that could be used during this routine to facilitate language. The importance of talking throughout the entire day was stressed despite the focus on the daily routine; participants were encouraged to use strategies discussed not only during the hour-long routine but all day. Finally, a goal was set for the next week's conversational turn count, and this goal was adjusted each week based on performance. Each time participants reached the weekly goal in conversational turns they received gift cards.

Follow-up meetings were held roughly every two weeks. Here the therapist showed participants LENA output graphs to see if improvements had been achieved. Parents asked questions and shared their concerns about the strategies they were practicing and the therapist engaged them in a discussion about how to improve their language skills with their son.

Data Collection & Selection

DLP's were distributed to families three at a time with the intention of parents making recordings three days per week. DLP recordings must have been at least 8 hours long to be

analyzed and considered valid by LENA. RETOLD researchers averaged the data of each set of three LENA recordings to obtain one datum point. Baseline was achieved after 12 valid LENA recordings that made up 4 baseline data points. LENA recordings continued to be collected in groups of 3 after intervention was introduced, although this reduced to one recording per month during maintenance. A complete list of all recorded information and their LENA outputs is available in Appendix B, Table B1.

Due to technological challenges, only two baseline LENA recordings were available to be transcribed. These recordings had means of 8,081 adult words (22nd percentile) and 356 conversational turns (28th percentile) according to LENA counts, which closely matched the means of the 12 baseline recordings (as can be seen in Table 1). Post-intervention recordings selected were those with the highest percentiles in adult words and conversational turns in order to achieve the greatest possible contrast between pre- and post-intervention data. However, 4 of the top-rated recorded days were eliminated as options to be transcribed because they consisted of days when the child attended speech therapy and where a substantial amount of adult words and conversational turns involved the speech-language pathologist rather than the parents. The three selected post-intervention recordings had means of 18,861 adult words (81st percentile) and 883 conversational turns (75th percentile) according to LENA counts.

Transcription & Independent Variable Counts

After days of LENA recordings were selected for analysis, segments throughout the day were listened to and transcribed (see Table A1 for transcription conventions). LENA breaks recordings into five-minute time-coded segments, and all segments that LENA coded as containing adult words were listened to. All parental speech in these segments was transcribed orthographically and all child vocalizations were noted (specific words of the child were transcribed when they were recognizable, see Figure A1 for example). Only adult speech that

was spoken by the mother or father participating in the study was transcribed; all other adults or children were not transcribed. The child's crying was not transcribed as speech, but was recorded in a bracketed note to provide context when referring back to transcription documents (see Table A1).

Conventions of this original transcript formatting are provided in Table A1, with an example transcript provided in Figure A1. All words by a single speaker were transcribed in the same line with no line breaks between utterances or sentences, although end of utterance markers were used (periods, question marks, and exclamation points). Internal punctuation also was used, namely commas or apostrophes. Any child speech that was unintelligible was indicated with the letter "v" to indicate a vocalization.

Pound signs (#) were used to indicate breaks in conversations. LENA uses a time lapse of more than 5 seconds to determine where breaks in conversation occur; this was in general the rule used in transcription, although if there is a lapse longer than 5 seconds and conversation picks back up with seemingly no stop, the transcriber used her discretion to determine whether this was indeed a break in conversation (an example of this may be if the adult asks the child a question and the child takes longer than 5 seconds to respond). Breaks in conversation also were coded when there was no pause in speech but when the conversational partners shifted (e.g., conversation between the mother and the father shifted to conversation between the father and the child).

The original transcripts in this format were run through a custom computer program (code available in Figure A3) to determine the number of conversational turns, child-directed adult words, and non-child-directed adult words.

Data Coding and Utterance-Level Analysis

Original transcripts in the above format were uploaded into an Excel file, with one utterance per line, and analyzed (see Table A2 for an example). The means for the total number of adult utterances per day were 1,379 in baseline and 1,893 after intervention, of which means of 1,016 in baseline and 1,085 after intervention were child-directed (see Table 1). All adult utterances that were child-directed were analyzed as follows.

Language "quality" is a broad term encompassing many features of language, and linguists do not necessarily agree on which aspects are most important to early language development. This study examines only a small subset of these features, selected based largely on procedures used by Hart and Risley (1995, 1999). Three features were examined: the types of questions parents asked, the types of feedback they gave, and how interactions between parent and child start. See Table 2 for definitions and examples. These categories were further dissected by identifying which utterances were facilitative in terms of promoting child language development.

The total number of questions was determined and then each was categorized as a WH or Yes/No question. The total number of feedback utterances was determined then each was categorized as either positive or negative. The total number of starts of interactions was determined then each was categorized as either an initiation or response. Hart and Risley (1999) argue that WH-questions " (asking "Who", "What", "When", "Where", "Why", and "How"), which request novel answers and probe further, are of higher quality than Yes/No questions, which typically require one word answers with little elaboration necessary. Likewise, positive feedback, which is encouraging in tone and manner and often praises a child's speech or behavior, is considered of higher quality than negative feedback, which discourages or prohibits speech or behavior. Hart and Risley did not suggest that either initiations or responses were of

higher quality, but for the purposes of the RETOLD study this measure was considered useful in determining if parents were initiating and continuing conversation more often as a result of intervention.

Each utterance that fell into the three categories of dependent variables was also categorized as either facilitative or non-facilitative. Facilitative utterances were utterances that actively promoted child language by modeling elaborated linguistic information or by requiring the child to formulate a response other than "yes" or "no." This method of coding helped give researchers a better idea of which utterances were actively promoting language and should be targeted further in intervention. It is important to note that non-facilitative language is not harmful to the child's language learning, but is simply the remainder of coded utterances that do not specifically promote language learning. This study primarily assessed the changes in facilitative language. Statistical analysis performed on these categories included the chi-square test of significance on raw numbers and the two-proportion Z test on proportions.

It is important to note that these variables (Facilitative/Non Facilitative Questions, Facilitative/Non Facilitative Starts of Interactions, and Facilitative/Non Facilitative Feedback) are not necessarily mutually exclusive. Some overlap occurs between utterances, for example, a child's exclamation of "Truck!" followed by the parent utterance "Is that a truck?" is categorized as a question (facilitative yes/no), a start of interaction (facilitative response) and feedback (repetition, facilitative positive feedback). Where pertinent, the extent of overlap is summarized in the results below, and a complete list is available in Table B2.

Word-Level Analysis

In addition to coding analysis done by hand, original transcripts were reformatted using SALT conventions (see Table A3 for conventions and Figure A2 for example transcript) and SALT was used to obtain the number of word types and tokens as well as the type/token ratio.

Word types and type/token ratio measures are used by researchers to assess vocabulary diversity, and research indicates that a higher SES is associated with parents producing higher numbers of both types and tokens (Hoff, 2003).

Results

The quantities of independent variables, adult words and conversational turns, are shown in Table 1. Based on LENA estimates of pre- and post-intervention, large increases in the mean numbers of adult words (22nd to the 47th Percentile) and conversational turns (28th to the 51st Percentile) were demonstrated. The means for the 12 pre-intervention days were very similar to the means for the two days selected for transcription based on LENA calculations. The selected post-intervention days were at the high end of the range for post-intervention LENA data overall.

The LENA estimates are compared to transcription estimates in Figures 1 and 2. Of the mean 1,016 child-directed utterances per day in baseline and 1,085 child-directed utterances per day post-intervention (as derived from transcription), 72% and 64% were coded and analyzed, respectively. The remaining non-coded child-directed utterances were not questions, starts of interactions, or feedback and were not analyzed in this study. Also not coded or analyzed at the utterance-level were any adult utterances that were not child-directed. Transcribed values tended to be lower than LENA estimates of adult words and conversational turns; however improvement in quantity was still evident for both variables, though to a lesser degree.

When comparing the number of child-directed words to the total number of total adult words from baseline to post-intervention, an unanticipated decrease in the proportion of child-directed words occurred. Thus, while the parents were speaking more words to their children overall (14.9% more), the total number of words the child overheard, or that were not spoken directly to the child, increased at a much higher rate (96.3%).

Question and Feedback Types

A complete list of variable results and significance is available in Table A2.

The types of questions asked and feedback given served as the initial measure of quality. For question types, a higher proportion of WH questions was considered of higher quality. While the mean raw number of WH questions (see Figure 3) increased 8.9% from 164 to 179, this gain was not statistically significant (X^2 (1) = 0.43, $p > .05$), and the proportion of WH questions out of all questions asked (see Figure 4) actually decreased slightly.

For feedback, a higher proportion of positive feedback than negative feedback was considered of higher quality. While both baseline and post-intervention feedback was overwhelmingly negative, there is a definite shift in the amount of positive versus negative feedback. From baseline to post-intervention, the raw number of positive feedback utterances (see Figure 5) increased by 24.5% and the raw number of negative feedback utterances decreased by 25.2%; this shift in raw numbers was statistically significant (X^2 (1) = 7.56, $p < .01$). The proportion of feedback that was positive (see Figure 6) shifted from 15.7% in baseline to 23.7% post-intervention, a change that was also statistically significant (Z (1) = 4.98, $p < .01$). Further, the shift in the proportion of all child-directed utterances that were negative feedback utterances (34.1% to 23.9%, see Figure 7) was statistically significant (Z (1) = 8.36, $p < .01$). Thus, while the desired proportion of more positive than negative feedback was not reached, it is obvious that improvement occurred.

Starts of interactions were not evaluated at this broad level in terms of quality because it has not been established whether a greater number of initiations or responses is more beneficial to the child's language development or if the relationship is irrelevant. For the purpose of the RETOLD study, however, researchers were interested in seeing whether parents were initiating

interactions more after intervention; while the raw number of initiations (see Figure 8) increased 19.8% from 86 to 103, this shift was not statistically significant (X^2 (1) = 3.50, p > .05).

Facilitative versus Non-Facilitative Utterances

Utterances that were facilitative were compared pre- and post-intervention. The number of facilitative utterances (see Figure 9) increased 39% from 124 to 171, a statistically significant improvement (X^2 (1) = 5.74, p < .05). (The total raw number of facilitative utterances reflects the sum of facilitative questions, starts of interactions, and feedback, excluding 56 overlaps in baseline and 24 overlaps in post-intervention. Some single utterances contributed to the total of more than one of these individual categories, creating an overlap, and had to be excluded from the combined total of all categories in order to avoid counting a single utterance twice.) The number of non-facilitative utterances declined from 624 to 539 pre- versus post-intervention. The overall the proportion of all child-directed utterances (see Figure 10) that were facilitative remained low and only increased from 12.2% to 15.8%, though this was statistically significant (Z (1) = 3.82, p < .01).

The aspect of facilitative language that showed the most significant improvement was starts of interactions, in which a significant improvement in facilitative initiations was evident. This variable experienced a 91.5% improvement in raw numbers (see Figure 8), with mean facilitative initiations increasing from 24 in baseline to 45 after intervention, a statistically significant change (X^2 (1) = 5.38, p < .05). The improvement in the proportion of facilitative initiations to all initiations (see Figure 11) (27.5% to 43.8%) was also statistically significant (Z (1) = 5.12, p < .01). Additionally, the change in the proportion of all starts of interactions that were facilitative (10.4% to 20. 3%) reached significance (Z (1) = 5.34, p < .01), as did the change in the proportion of all facilitative starts of interactions to all child-directed utterances

(2.3% to 4.1%) ($Z(1) = 2.06$, $p < .01$). Facilitative responses saw no significant improvement, increasing from only 10 to 12.

Facilitative feedback showed moderate improvement. The mean number of feedback utterances that were facilitative (see Figure 5) increased by 20.4% (from 47 to 56) and this was statistically significant ($X^2(1) = 4.22$, $p < .05$). Although the proportion of all feedback that was facilitative (see Figure 6) increased (11.3% to 16.5%) and was statistically significant ($Z(1) = 3.24$, $p < .01$) due to the increase in raw positive feedback utterances overall, the proportion of positive feedback that was facilitative decreased slightly (72.1% to 69.7%). Facilitative questions showed little change (52 to 59 and 32.6% to 34.1%, pre- versus post-intervention, respectively) and were not significant.

Word-Level Analysis

The mean number of word types (see Table 3) increased both for child-directed words and for all adult words, indicating about a 15% and 28% increase in vocabulary diversity, respectively. However, the type/token ratios for baseline and post-intervention data did not change. The ratio for child-directed words remained constant at 0.10 and the ratio for all adult words actually decreased slightly from 0.10 to 0.08.

Discussion

The hypothesis that an increase in the quantity of language would be accompanied by an increase in the quality of talk and the proportion of facilitative language was not fully supported by the results of this study. While increases in the raw number of facilitative utterances and in the proportion of facilitative utterances overall were statistically significant, this success was not seen in all three quality categories and may not be reflective of broad improvements in quality.

Overall gains in the raw numbers of facilitative utterances were evident in both starts of interactions and feedback. This increase in raw numbers was to be expected, as the RETOLD

intervention was successful in helping the parents say more raw words to their child overall. Thus, one might expect an overall increase of roughly 15% reflecting the overall increase in the mean number of child-directed adult words. For word-level analysis, the improvement in vocabulary diversity of child-directed words (as measured by the number of word types) only increased by 15%, which means no real improvement was seen when the overall 15% increase in the number of child-directed words is taken into account. It does appear that an increase in the proportion of facilitative initiations and facilitative feedback occurred, however it is important to consider several caveats.

First, the definition of facilitative initiations was exclusive rather than inclusive. That is, a facilitative initiation is defined as any initiation excluding prohibitions or imperatives. Initiations that were categorized as facilitative were not necessarily promoting language development as directly as facilitative responses, questions, and feedback (which are all inclusive). For example, initiating an interaction by simply saying the child's name to get his attention (e.g. parent says, "Jimmy") does not actively promote language, but if the child answers (e.g. child responds, "Hm?") this parental utterance—which is an initiation but is not a prohibition or imperative—is categorized as facilitative. Additionally, facilitative initiations experienced such a great improvement both in raw numbers and proportionally that the number and proportion of facilitative utterances overall could have been skewed slightly. Second, although the proportion of facilitative feedback appeared to increase significantly, it was only the raw number of facilitative positive feedback, not the proportion of positive feedback that was facilitative, that improved. While improvement is obviously evident, the degree to which the intervention was successful in increasing the quality of language was not as strongly supported. In fact, the proportion of all adult words that were child-directed decreased from baseline to post-intervention (from 54.8% to 41.5%), indicating that there was no proportional improvement in

the quantity of child-directed speech as a result of intervention. In summary, the expected improvement in the proportion of child-directed utterances that are likely to promote language development did not result from intervention.

Note About Feedback

It is important to note that negative feedback is not detrimental to language learning; prohibitions are necessary to some extent in any parenting regardless of economic class. However, in higher income homes negative feedback is surpassed by a much higher proportion of positive feedback (Hart & Risley, 1995). It can be further speculated that much of the language in higher SES homes that is prohibitive in nature or intent is much less direct and thus may not be categorized as negative feedback. For example, while a common phrase of the family was "Stop, don't do that," in a higher income family the same goal of prohibiting the child's behavior may be accomplished with a suggestion and further explanation—for example, "Let's not throw that, we don't want to break it."

RETOLD Intervention Evaluation and Suggestions for Modification

It appears that starts of interactions—specifically initiations—were the easiest to increase. This may be due to the fact that the RETOLD intervention specifically targeted quantity and worked with parents on increasing interactions with their child, which could have innately helped parents use more facilitative utterances to initiate interaction. Similarly, the improvement in positive and facilitative feedback may also be attributed to the intervention strategies parents learned to respond to their children more often to continue an interaction and increase conversational turns. It is possible that these two facets of language—which are arguably more closely associated with quantity—may be easier to target and change than question types. One modification to the RETOLD intervention may include either specifically

targeting starts of interactions and feedback to increase the effect already evident or attempting to address facilitative questions specifically, as these are currently not affected.

Reasons for the intervention's arguably weak effect on quality features of language can be speculated upon based on the challenges that the RETOLD team faced while working with this population. First, having a therapist simply tell participants what to do in regards to changing their child-directed language does not address the underlying issue of parents' inexperience with facilitative language. The participants in this study were talking to their children just as their parents talked to them and did not have the tools or knowledge to evaluate and improve their own child-directed speech. The fact that the intervention was designed to allow—and in some ways depend on—parental input in developing routines and strategies to increase the quantity of language created a barrier that parents may not have been able to cross without further assistance. As such, a more structured intervention with specific activities or strategies outlined may be beneficial. For example, providing specific word games that parents can play with their children will offer them language-facilitating activities to supplement their daily routines and potentially give them a springboard to come up with other activities on their own. Additionally, practicing book reading skills and discussing the specific aspects of this activity that are facilitative—such as asking the child questions and elaborating on the words on the page—may be useful. Being direct about what specific aspects of their language will promote their child's language learning may also help parents gain understanding of how they need to alter their speech. For example, explaining that they should reinforce their child's use of language with praise, repetitions, and expansions or ask WH questions to obtain specific answers (rather than simply requesting repetition) may be the specific direction they need to improve upon quality of language. In general, providing participants with instructions on exactly what

they should be doing may be less intimidating than having an open discussion where parents are expected to give their input.

Peer models and focus groups may be another way parents can learn via observation and participation rather than abstractly talking about strategies. A possible peer model could be one of the parents interested in the RETOLD study who did not qualify to receive intervention because her baseline data was already above the 50th percentile in both adult words and conversational turns. Transcribing what this mother was saying to her children to achieve such high numbers may be valuable in identifying strategies that can feasibly be utilized in low-income homes. These strategies can then be shared by the peer model in focus groups or through video recordings of models interacting with their children.

Another challenge that the team faced with this family was that the participating 2-year-old was the parents' youngest child, so they had been parenting their older children for about 15 years prior to the start of the RETOLD study. Introducing new and different methods of parenting and speaking to one's children after established habits have existed for so long is difficult. Had the participants been newer parents they may have had an easier time of adopting the intervention strategies. It may be beneficial for the RETOLD intervention to target expectant mothers rather than those who already have children so that structured intervention procedures can be practiced before parenting begins. Whether this will impact parents' ability to learn and use intervention strategies more effectively, it will help ensure that their children are receiving quality language input without delay, provided that intervention is successful; rather than having to "catch up" to their higher-income peers, children will experience linguistic environments that promote language development immediately.

Lastly, before the intervention's impact on quality is deemed either significant or insignificant, it is important to remember that this was a case study. A more comprehensive

study of multiple families is needed before claiming this intervention as ineffective or not in this regard. It is possible that with other families this intervention could have been more successful at increasing the true proportion of facilitative language. Further, even if no families experienced an increase in facilitative language, patterns and habits exhibited by multiple families may be useful in modifying the intervention. However, regardless of the narrow scope of this study, the results are still valuable in tailoring the intervention to more specifically address the quality of language for all future participants.

Limitations and Implications

As previously mentioned, one limitation of this study is that it is a case study and only examines one family; external validity and generalizability of these results to other families and participants cannot be established as of yet. Additionally, internal validity and reliability were not established because only one person transcribed and analyzed the data. This was largely due to the fact that this was an individual undergraduate thesis, but also to the extremely time-intensive process of transcription and analysis. Related to the issues of validity and reliability is the difficulty the RETOLD research team had in recruiting participants despite outreach to schools, churches, daycares, and hospitals. Many of the suggestions for intervention modifications are dependent on finding more participants. Researchers need to determine what is deterring parents from participating—whether it be the perceived intrusiveness of recording language throughout the day, the chaotic aspects of coping with poverty, or other unforeseen reasons—and attempt to modify the study or perhaps the incentives to appeal to more participants.

Another limitation of this study was the variability between recorded LENA outputs and transcribed results in terms of numbers of adult words and conversational turns. LENA tends to overestimate these variables, which has implications for the actual magnitude of quantity

improvements; while gains are still evident, they are not nearly as pronounced as LENA led researchers to believe. Reasons for these discrepancies are due to inherent limitations of LENA technology. LENA analyzes sound waves and latencies between different speakers to determine the number of adult words, child vocalizations, and conversational turns; however, it cannot account for some situations that arise on a daily basis. For example, if a parent is on the phone and the child is talking to himself at the same time, LENA interprets the interaction of these lower and high frequency speech waves as a conversation when in reality there is no interaction between parent and child. Additionally, older children (particularly males, as with the 15-year-old son in this study) are often interpreted by LENA as adult speakers. Finally, although LENA can distinguish between male and female adult speakers, if parents are the subject of analysis there is no way to know how much of the adult words are spoken by them and not other adults (such as the speech-language pathologist in this study). These situations make it difficult to identify which times during the day are actually highest in true adult words and conversational turns. While this study originally intended to transcribe only the segments of the day with the highest rates of conversation, this misleading information forced the transcription of entire days to ensure that the highest rates were captured and analyzed. LENA was a wonderful tool to estimate language input provided to children and to eliminate the necessity of listening to every minute of each day by identifying segments where no speech occurred (e.g. during naptime); nevertheless, the limitations of the technology need to be considered and accounted for by any researchers utilizing it in the future.

Lastly, while there is normative data from Hart & Risley (1995) regarding the means for WH questions and positive versus negative feedback in higher SES homes, variables termed "facilitative" by this study do not have norms for higher SES homes to refer to. Researchers must bear in mind that (for example) though the proportion of facilitative utterances in this low

SES home was small (no more than roughly 15%) even after intervention, the proportion of child-directed speech in higher SES homes that is facilitative could also approximate these numbers. If this were the case, then the intervention may have been more successful creating language environments similar to those in higher SES homes.

Future Research

The RETOLD intervention should not be discarded; it did have a positive effect on the quantity of language as well as some impact on the quality, and future research should include modifications to the intervention as discussed above. One facet of this study that piqued this researcher's curiosity and warrants further inspection was feedback, or the perception of feedback as either positive, negative, or neutral. The transcriber and analyst in this study was a Caucasian, middle class college student and may have interpreted more utterances to be negative than the parents of this study, who were African Americans with a high school education. It is possible that the social and cultural differences in talking to children are causing some of the difficulties these parents experience in being able to identify aspects of their speech, such as negative feedback, that is not facilitative.

Other interesting research that could be initiated using LENA is a detailed analysis of the relationship between television and the quantity of language, as a general trend observed in LENA outputs was a decrease in the number of adult words, child vocalizations, and conversational turns when the television was on. Similarly, cell phone usage appeared to negatively impact the amount of child-directed speech that occurred. It would be interesting to compare this observation to speech in households of higher SES homes; does the amount of cell phone usage compare to that of lower SES homes, and does it have the same negative effect?

Lastly, a comparison of interactions with the child by both parents and older siblings may yield interesting results. Although sibling interactions with the child where not analyzed in this

study, siblings seemed to display a higher rate of facilitative language, possibly because their interactions consisted of more play and voluntary conversations rather than mostly imperatives or prohibitions. If these siblings in lower SES households are already exhibiting language that is more similar to that of higher SES parents, it may be beneficial to capitalize on their skills to teach parents how to increase their facilitative language. Further investigation of any of these issues would potentially prove useful in the scope of the Project RETOLD , and the modifications made to the intervention as a result could have monumental effects on the amount of quality, facilitative language spoken to children in low SES homes.

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Tables & Figures

Table 1

Summary of Independent Variable Findings: LENA Output Versus Manual Transcription

Variable	Baseline			Post Intervention		
	LENA Estimates	LENA Selected Days	Transcribed	LENA Estimates	LENA Selected Days	Transcribed
Number of Recordings	12	**2**	**2**	19	**3**	**3**
Mean *(SD)* Adult Words (AW)	8,080 *(2968)*	8,081 *(NA)*	**5489**	12,939 *(4858)*	18,861 *(883)*	**8327**
AW Percentile Rank	22	22	**--**	47	81	**--**
Mean *(SD)* Conversational Turns (CT)	313 *(96)*	356 *(NA)*	**454**	580 *(187)*	883 *(43)*	**551**
CT Percentile Rank	28	20	**--**	50	75	**--**
Mean Child-Directed Words (CDW) per day	--		3010	--		3459
Percent CDW of all Adult Words	--		54.8%	--		41.5%
Mean Child-Directed Utterances (CDU) per day	--		1016	--		1085
Percent CDU of all Adult Utterances	--		73.7%	--		57.3%
Mean Non-Child Directed Utterances	--		363	--		808
Mean Total Adult Utterances per day	--		1379	--		1893

Table 2

Definitions and Examples for the Variables Coded from Transcripts

Variable	Definition	Example(s)	Exclusions
Conversational Turns (CT)	Turn-taking between child and at least one adult. Consists of an utterance followed by a comment by a conversational partner and, if at the start of an interaction, ending with a comment by the original speaker	I CT = Child-Adult-Child 2 CT = Adult-Child-Adult-Child 3 CT = Child-Adult-Child-Adult-Child	
Adult Words (AW) or Utterances	All transcribed words/ utterances spoken by participants, i.e. mother and father, in the vicinity of child's recorder so speech is audible		
Child-Directed (CD) Adult Words or Utterances	All transcribed adult words/utterances that are spoken directly to the child. All utterance-level analyses deal with Child-Directed Utterances.		
Facilitative Utterances	**Any utterances that actively promotes child language by providing valuable linguistic information or requiring the child to formulate a response other than "yes" or "no"**		
Questions			
Facilitative WH Qs	Any WH-question that does NOT include one-word requests for the child to repeat an utterance or prohibitive rhetorical questions	"What are you doing?" "How's it going?"	"What?" or "Huh?" "What did I just say!?" (often followed by "I said don't do that!")
Facilitative Yes/No Qs	Yes/No question stating information with the purpose of providing information or modeling; is often somewhat rhetorical	"Is that a truck?" "Are you jumping up and down?"	

Starts of Interactions	Following a latency of about 5 seconds within which no conversation occurs, a first speaker initiates the interaction and a second speaker responds. Sometimes continues into a full conversational turn and conversation.		
Facilitative Initiations	Start of interaction initiated by a parent (i.e. parent is first speaker) that promotes further language or requests language. Does NOT include imperatives of prohibitions.	"What are you doing?" "Are you having fun?" "Tell me about your book."	"Come here." "Stop that!"
Facilitative Responses	Parental response to child initiation of interaction (i.e. parent is second speaker) that prompts further language or requests more language. Does NOT include imperatives or prohibitions or one-word requests for child to repeat an utterances.	"What are you doing?" "Are you having fun?" "Tell me about your book."	"What?" or "Huh?" "What did I just say!? [often followed by "I said don't do that!"]
Positive Feedback	Responses to any child action or utterance that approve behavior or express affection Also includes any facilitative positive feedback such as repetitions, expansions, or language-encouraging utterances.	"Good job!" "I love you."	
Repetitions	Repetition of some part of child's utterance	Child: "Balloon!" Parent: "Balloon!"	
Expansions	Restatement of child's words into a fuller, more grammatically correct utterance or providing more information about something the child just said	Child: "Truck!" Parent: "That's a truck, it's really big!"	
Language-Encouraging Utterances	Encourages, approves, or validates child's use of language	Child: "Red!" Parent: "Uh-huh." or "You're right, that's red."	

Negative Feedback	Prohibitions or other negative comments in response to the child's actions or language	"Stop that!" "You're getting on my nerves."
Type/Token Ratio	Ratio of number of word types to number of word tokens. A measure of vocabulary diversity.	
Word Types	Number of different word roots	"run" and "running" = 1 type
Word Tokens	Number of total words	"run", "run", and "running" = 3 tokens

Table 3

Mean Word-Level Variable Analysis

Variable	Baseline	Post Intervention	Percent Improvement
	Child-Directed Words		
Number of Word Types	301	345	14.8%
Number of Word Tokens	3010	3459	14.9%
Type/Token Ratio	0.10	0.10	-0.1%
	Other Adult Words (Non Child-Directed)		
Number of Word Types	416	554	--
Number of Word Tokens	2479	4867	--
Type/Token Ratio	0.17	0.11	--
	All Adult Words		
Number of Word Types	541	694	28.3%
Number of Word Tokens	5489	8327	51.7%
Type/Token Ratio	0.10	0.08	-15.4%

Note: Number of Word Tokens is an independent variable but is included in this table to show how the type/token ratio was derived.

Figure 1 Comparison of Adult Word (AW) Counts Between LENA and Transcription

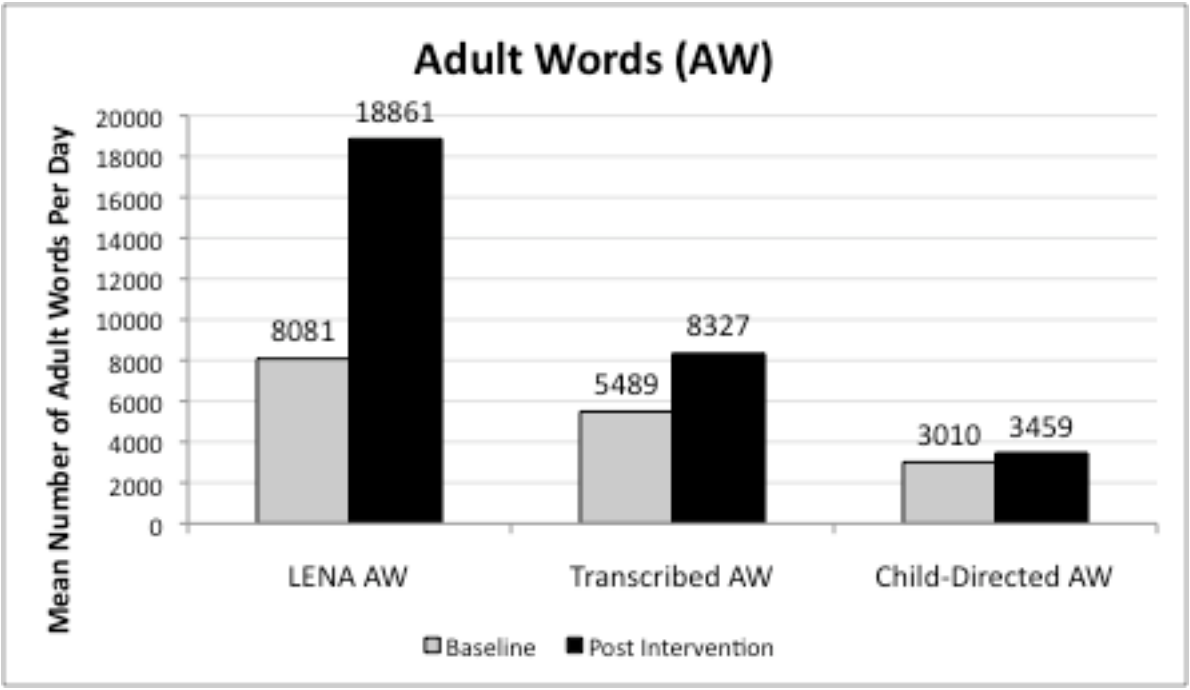


Figure 2 Comparison of Conversational Turn (CT) Counts Between LENA and Transcription

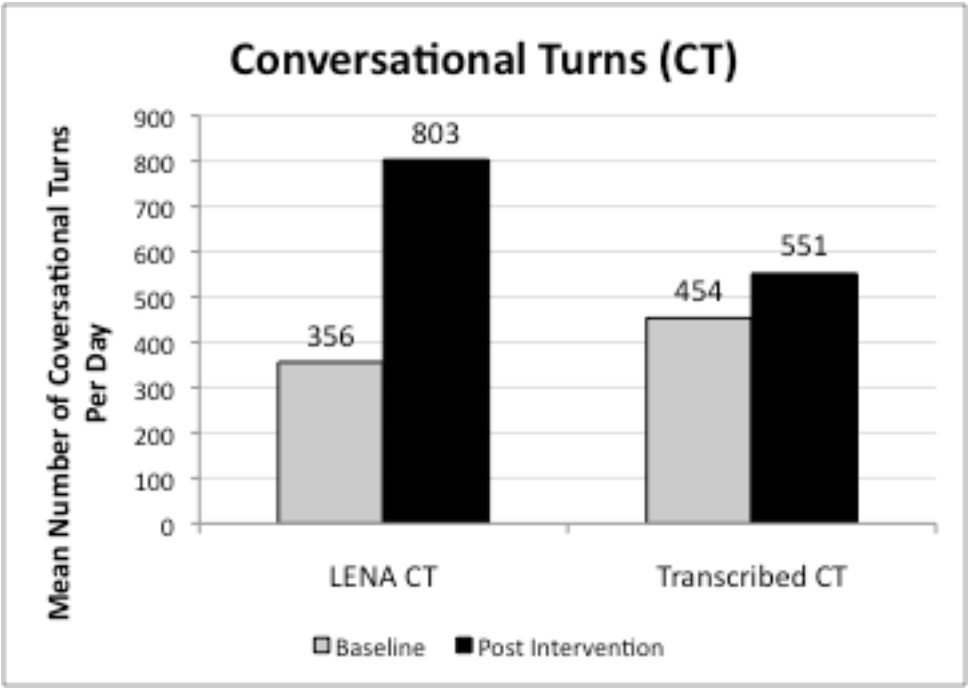


Figure 3 Mean Number of Questions by Type and Quality

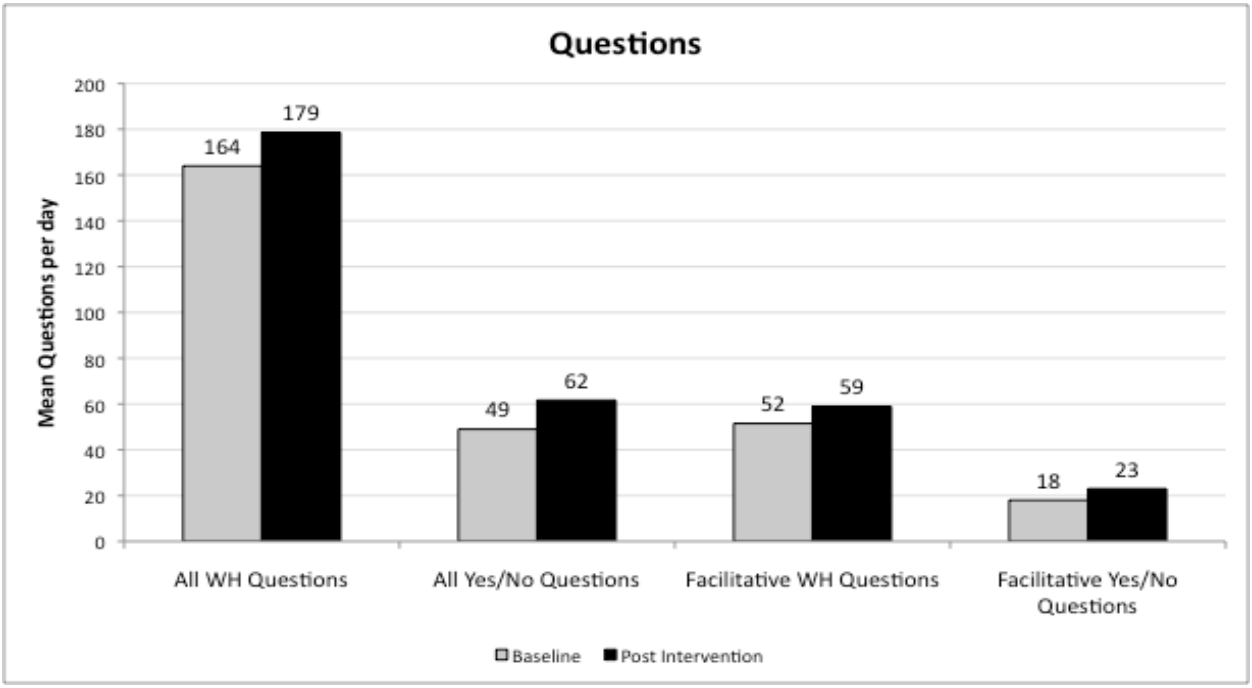
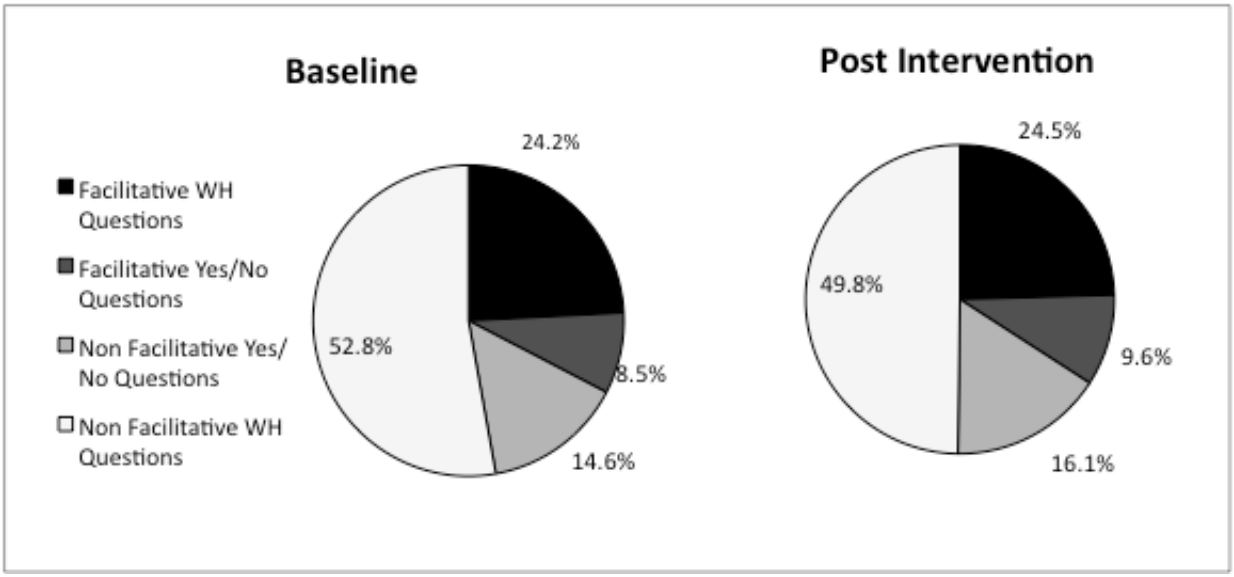


Figure 4 Proportion of Questions by Quality



Note: Baseline proportion of all questions that were WH questions was 77.0%. Post Intervention proportion was 75.3%.

Figure 5 Mean Number of Feedback Utterances by Type and Quality

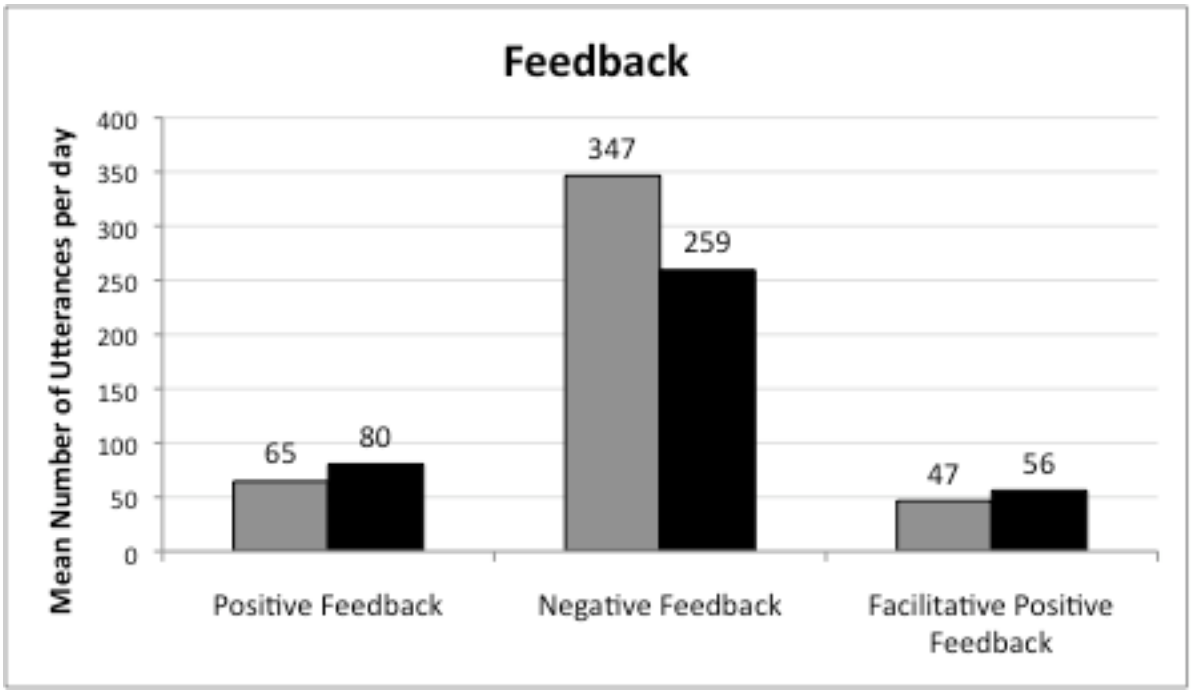
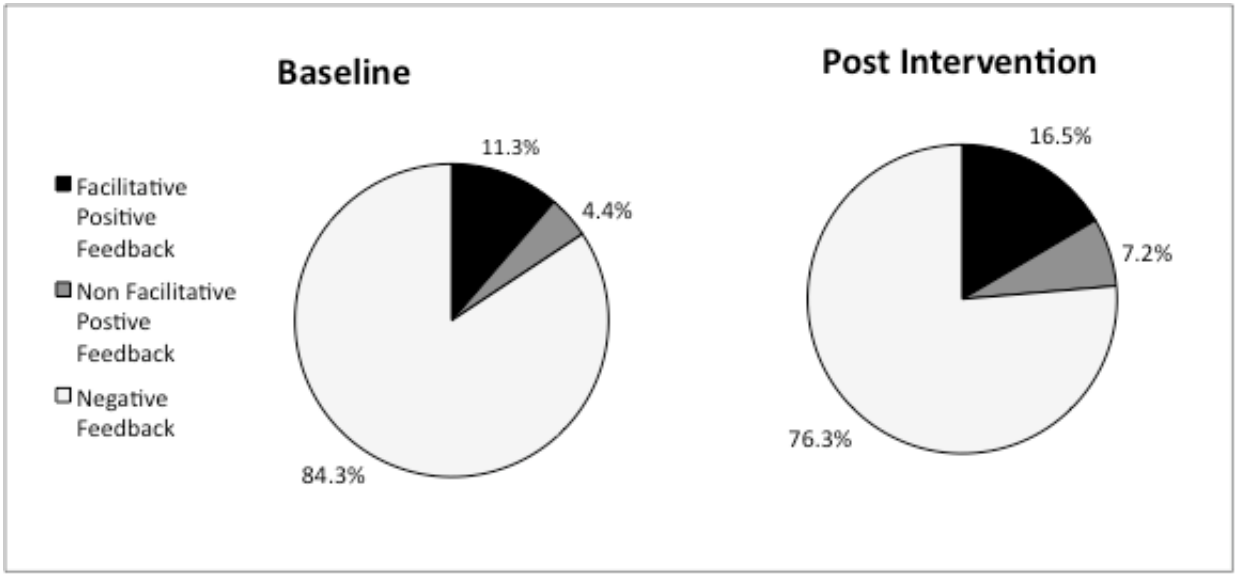
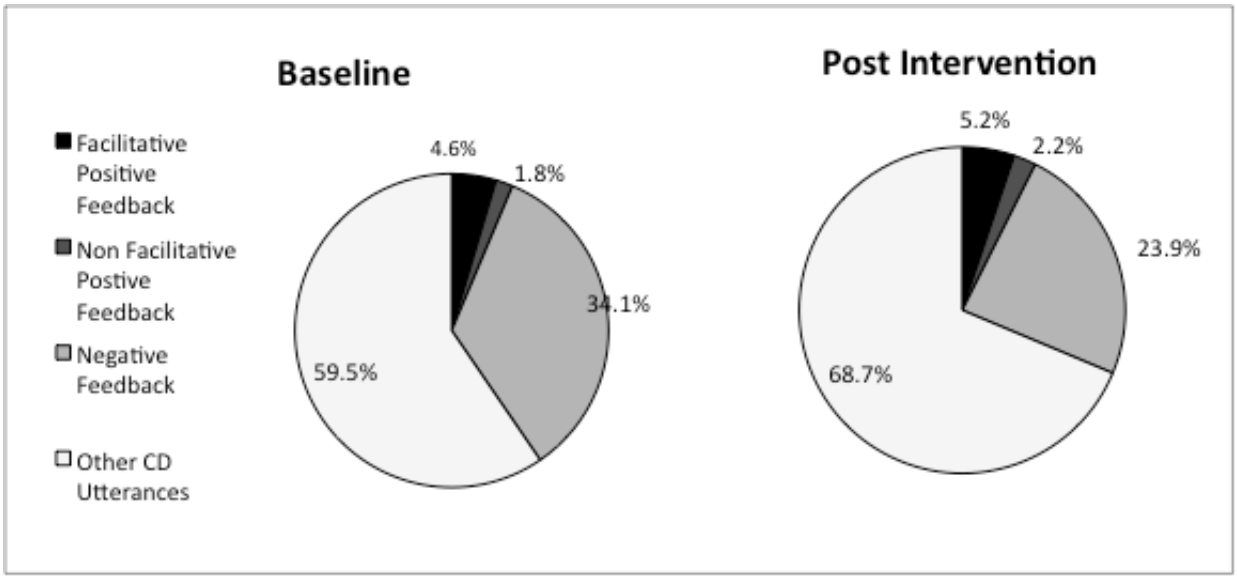


Figure 6 Proportion of Feedback by Quality



Note: Baseline proportion of all feedback utterances that were positive was 15.7%. Post Intervention proportion was 23.7%.

Figure 7 Proportion of Feedback by Type of All Child-Directed (CD) Utterances



Note 1 *Baseline proportion of all child-directed utterances that were positive was 6.3%. Post Intervention proportion was 7.4%.*

Figure 8 Mean Number of Starts of Interactions by Type and Quality

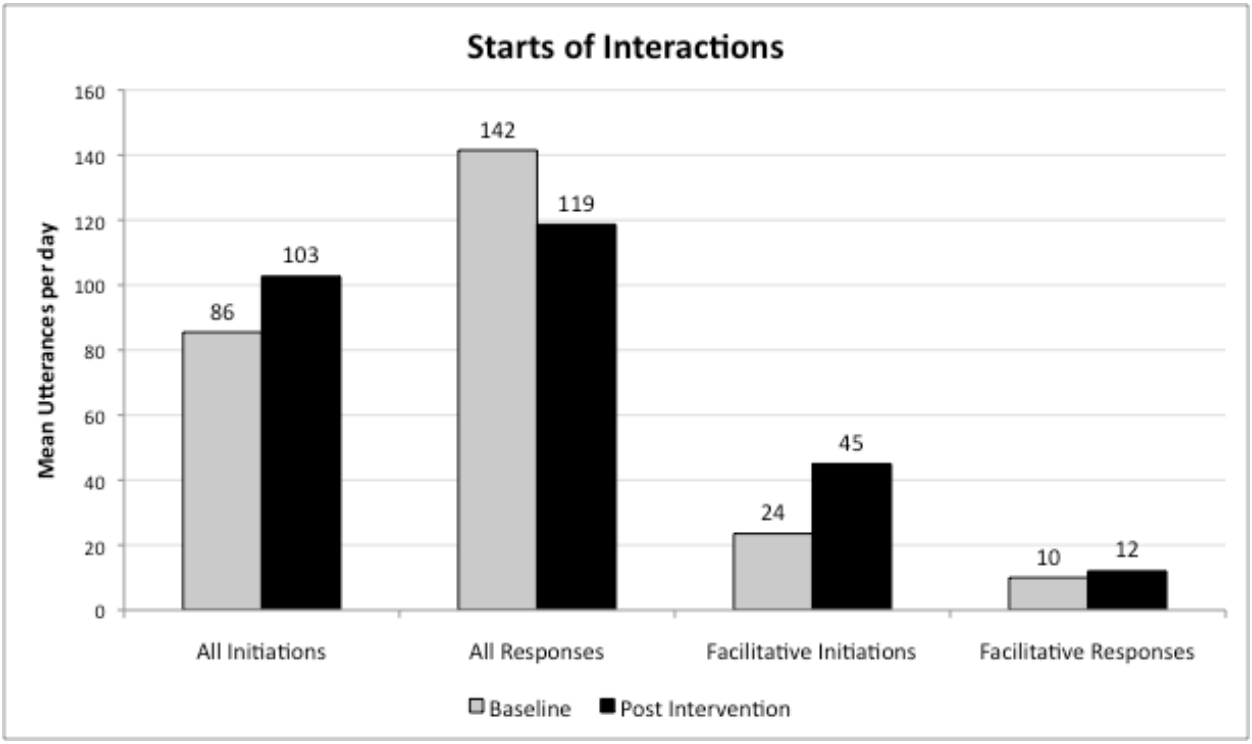


Figure 9 Total Child-Directed Utterances by Quality

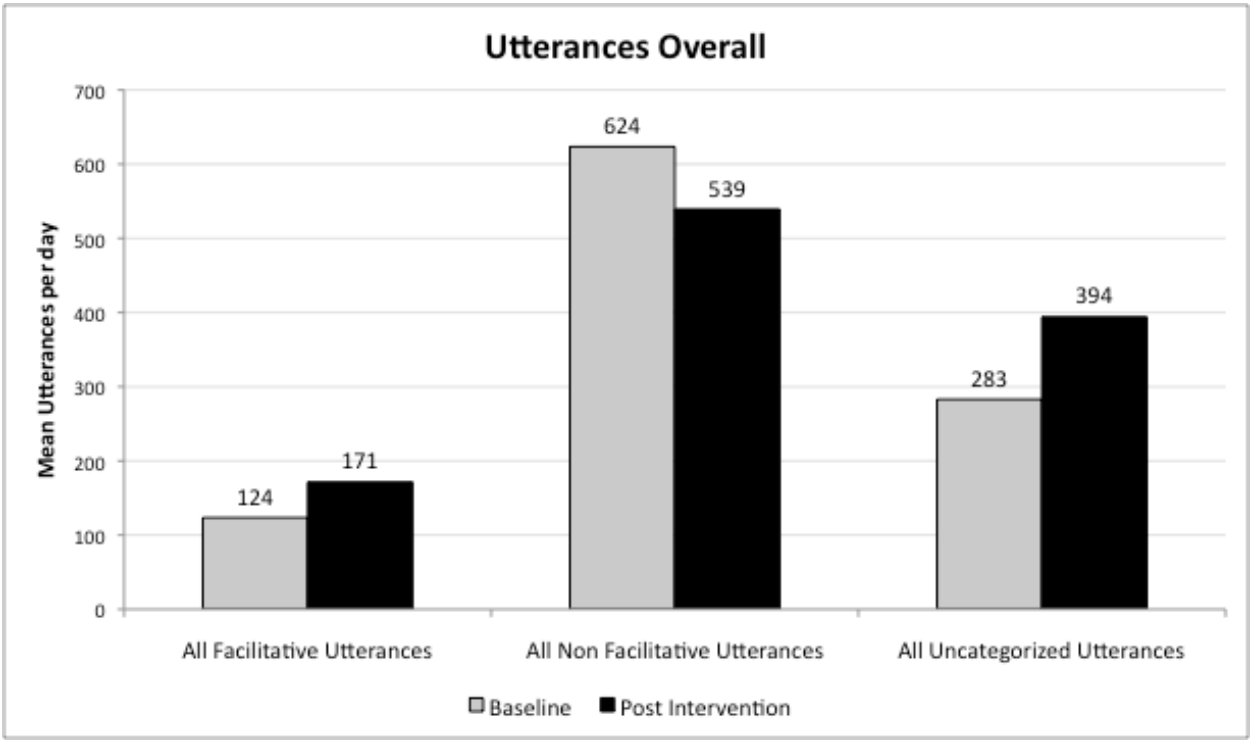


Figure 10 Proportion of Utterances by Quality

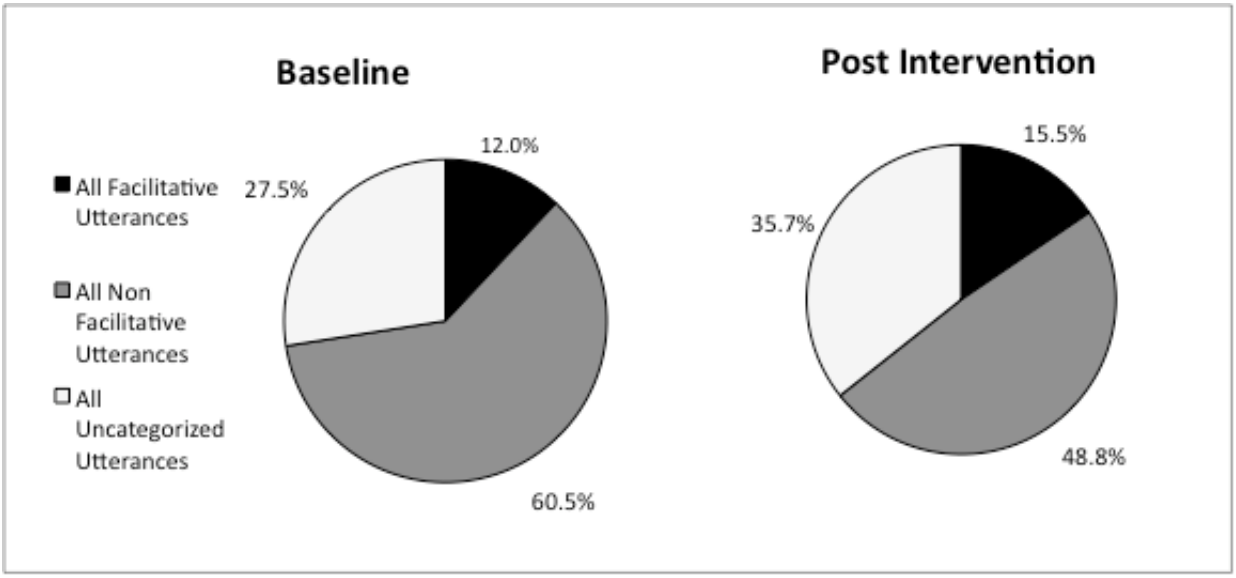
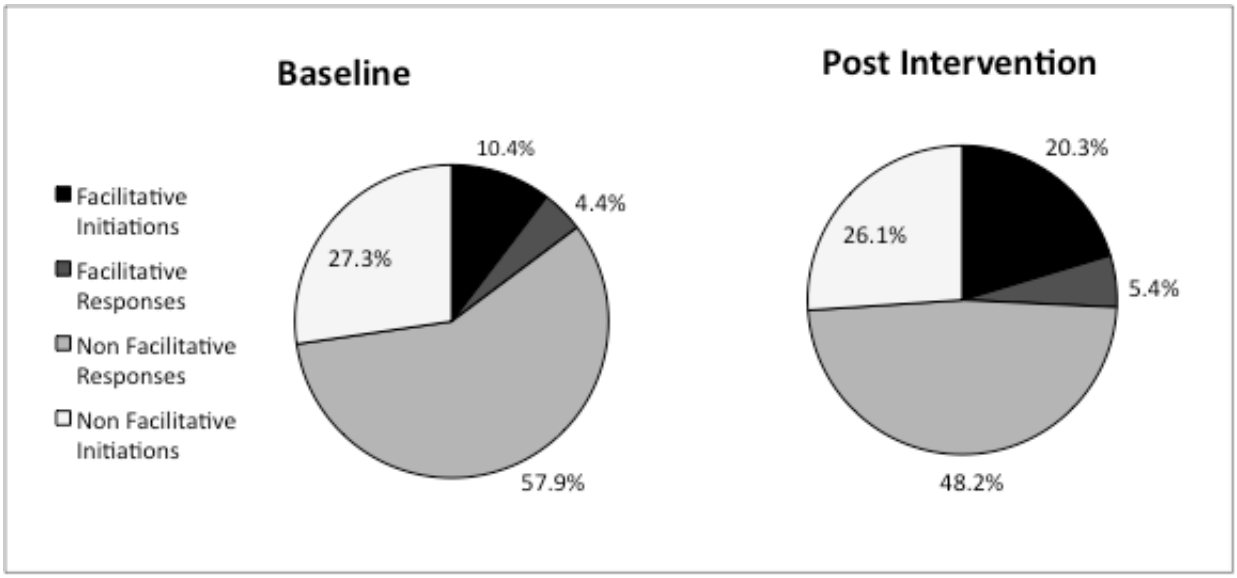


Figure 11 Proportion of Starts of Interactions by Quality



Note: Baseline proportion of all starts that were facilitative was 14.8%. Post Intervention proportion was 25.7%.

Appendix A

Transcription Conventions, Examples, & Program Code

Table A1

Codes and conventions used for original orthographic transcripts.

M:	Speech that follows is maternal speech that is child-directed
MM:	Speech that follows is maternal speech that is NOT child-directed
D:	Speech that follows is paternal speech that is child-directed
DD:	Speech that follows is paternal speech that is NOT child-directed
C:	Speech that follows is child speech/vocalizations
X: or XX:	Speech that follows is spoken by an adult other than the parents, either child-directed (single letter) or non-child-directed (double letter). Sometimes may not be transcribed and is left blank, since is not analyzed by this study.
K: or KK:	Speech that follows is spoken by a sibling or youth other than the child, either child-directed (single letter) or non-child-directed (double letter). Sometimes may not be transcribed and is left blank, since is not analyzed by this study.
v	Child speech that is unintelligible
xx	Word that is unintelligible
#	Indicates a break in conversation, generally consisting of a laspse of more than 5 seconds.
[note here]	Indicates notes to give context or aid the researcher in identifying certain situations. For example, [Dad is talking on the phone, speakerphone is on], [child is crying], [Mom is talking to sibling in background], [TV is on], etc.
xx:xxam or xx:xxpm	Time code format used to indicate at what time the five-minute segment starts, ex. 9:35am, 10:10pm

Note: "Child" always refers to the 24-month-old who was the subject of this study unless otherwise noted.

Table A2

Example of Excel spreadsheet used to code individual utterances.

Utterance	Questions				Start of Interaction					Feedback Utterance			
					Initiation		Response						
	Any Y/N Question	Facilitative Y/N Question	Any WH Question	Non Facilitative WH Question	Any Initiation	Imperative Prohibition	Any Response	Language Encouraging	Non Facilitative Question	Negative Feedback	Any Approval or (+) Feedback	Repetition/ Expansion	Language Encouraging	Any Prohibition or (-) Feedback
1:15pm														
D: Hey, what's wrong, man?			1		1									
What's wrong?			1											
DD: Why did you close it?														
What's he eaten?														
Oh, okay.														
D: Come here, Leroy!					1	1								
Come here, man!														
That's Jack.														
Say hi, Jack!														
C: v														
D: Uh-huh.											1		1	
You want to say to to Jack?	1													
C: v														
DD: Ok, man.														
I'll hollar at you later.														
#														
D: Get back, no!					1		1							
C: v														
DD: That's fine.														
I know it does, but you're gonna need it.														
#														
C: v														
D: What?			1	1				1		1				

Note: The only utterances that are categorized are parental child-directed utterances. Any line without a speaker indicator (e.g. "D:") was spoken by the most recent indicated speaker.

Note for tallying: NonFacilitative Y/N Questions = Any Y/N Qs – Facilitative Y/N Qs
Facilitative WH Questions = Any WH Qs – NonFacilitative WH Qs
Facilitative Initiations = Any Initiations – (Prohibitions + Imperatives)
NonFacilitative Initiations = Prohibition Initiaitons + Imperative Initiations
Facilitative Responses = Language Encouraging Responses
NonFacilitative Responses = Any Response – Language Encouraging Resp.
Facilitative Feedback = Repetition/Expansions + Lang Encouraging Feedbck
NonFacilitative Feedack = Any Neg Feedback + Any Pos Feedback – (Reps/Exps + Lang Encour Feedback)

Table A3

SALT conventions used for transcript reformatting.

Symbol	Description	Ex: Original	Ex: Reformatted
/3s	Third person singular verb	goes closes walks	go/3s close/3s walk/3s
/s	Regular plural noun	toys choices children	toy/s choice/s children (not applicable)
/z	Possessive noun	Daddy's Wade's	Daddy/z Wade/z
/s/z	Possessive plural noun	boys'	boy/s/z
/ing	Regular –ing verbs	walking running blaming	walk/ing run/ing blame/ing
/ed	Regular past-tense verbs (NOT adjectives like "tired")	walked went	walk/ed went (not applicable)
/n't	Regular negative contraction	couldn't ain't	could/n't ain't (not applicable)
/'xx	Regular contractions	could've I'll I'm I'd we're he's	could/'ve I/'ll I/'m I/'d we/'re he/'s
spoken/ real	Shortened words	cause [for "because"]	cause/because
%	Sound effects	beep beep	%beep_beep
%spoken {actual}	Idiosyncratic words, i.e. partial words used consistantly by child or family to represent a specific English word	pah-pah [for "pacifer"] boo-boo [for "poop"] baba [for "bottle"]	%pahpah {pacifier} %booboo {poop} %baba {bottle}
	Specific word spellings	okay uh-huh (affirmative, "yes") huh-uh (prohibitive, "no") uh-oh	OK UHHUH UHUH UHOH

Note: Colons and all punctuation as well as pound signs and bracketed text are deleted in this format, unless noted in this table as a SALT convention or any periods marking the end

of a speaker's turn. "Spoken" refers to the word actually spoken by the person and transcribed as such originally; "real" refers to the actual English word that the spoken word represents.

Figure A1

Example of time-coded original orthographic transcript.

1:15pm [Adult Words: 67, Conversational Turns: 7]
[Siblings talks, including oldest]
#
D: Hey, what's wrong, man? What's wrong?
#
DD: Why did you close it? What's he eaten? Oh, okay.
D: Come here, Leroy! Come here, man! That's Jack. Say hi, Jack!
C: v
D: Uh-huh. You want to say hi to Jack?
C: v
DD: Ok, man. I'll holler at you later.
#
D: Get back, no!
C: v
DD: That's fine. I know it does, but you're gonna need it.
#
C: v
D: What?
C: v
D: Be careful.
#
C: v
D: Stand up. Come here. Stand up.
C: v
#
D: Get your foot in there.
C: v
D: Be careful! Like that.
C: v
D: Go and sit down.
#
D: Right there. Push the button. Be careful. That's not the right one. No come and sit down.
[TV is on]
1:20pm [Adult Words: 15, Conversational Turns: 3]
D: Come on
C: pah-pah
D: You want some chips?
C: I want pah-pah
D: Daddy get it.
C: v
D: Wait a minute.
#
D: Want some chips?
C: v

Figure A2

Example of SALT formatted transcript (same transcribed speech as Figure A1)

D Hey what/'s wrong man What/'s wrong.
E Why did you close it What/'s he eaten Oh okay.
D Come here Leroy Come here man That/'s Jack Say hi Jack.
C v.
D UHHUH You want to say hi to Jack.
C v.
E Ok man I/'ll holler at you later.
D Get back no.
C v.
E That/'s fine I know it do/3s but you/'re gonna need it.
C v/
D What
C v.
D Be careful.
C v.
D Stand up Come here Stand up
C v.
D Get your foot in there
C v.
D Be careful Like that
C v.
D Go and sit down
D Right there Push the button Be careful That/'s not the right one No come and sit down.
D Come on.
C %pahpah {pacifier}.
D You want some chip/s.
C I want %pahpah {pacifier}.
D Daddy get it.
C v.
D Wait a minute
D Want some chip/s.
C v.

Note: All parental words that are NOT child-directed are indicated with the speaker code "E". SALT was used to count the number of different tokens and the type/token ratio for all adult words and all child-directed adult words. All lines end with a period regardless of utterance type; this was the easiest way to collectively reformat entire transcript documents and does not affect the type or token counts or the type/token ratio.

Figure A3

Code for custom computer program to count all adult words, all child-directed adult words, and all conversational turns. Written by Zach Smith. Transcripts must be in the format indicated in Figure B1 in order to utilize this program.

The program requires that you have the JDK version 1.6 or greater installed on your system. If this requirement is met, then the program can be run by executing the following commands within a command prompt (the ">" used below represents the terminal's prompt for user input):

> javac DocumentScanner.java

And then:

> java DocumentScanner -file [path to input file]

```
import java.io.*;
import java.util.ArrayList;
import java.util.List;
import java.util.StringTokenizer;
import java.util.regex.Pattern;

public class DocumentScanner {

    private static String fileName;

    // One or more digit followed by 0 or more anything
    private static Pattern timestamp = Pattern.compile("\\d+.*");

    public static void main(String[] args) throws IOException {
        parseInputs(args);
        // Broken up by line
        List<String> contents = readFile(new File(fileName));
        // Delimited by #
        String speakerString = "";

        for (String line : contents) {
            StringTokenizer tokenizer = new StringTokenizer(line);
            // We only care about the first token, so this is an if and
not a while. It wouldn't loop anyway
            if (tokenizer.hasMoreTokens()) {
                // Advance past the first token, which is the speaker
designation
                String token = tokenizer.nextToken();
                speakerString += token;
                // Add it to the list of speakers
                SPEAKER_TYPES speaker = getSpeakerType(token);

                if (speaker != null) {
                    switch (speaker) {
                        case DAD: {
                            SPEAKER_TYPES.DAD.wordCount +=
tokenizer.countTokens();
                            break;
                        }
                        case MOM: {
                            SPEAKER_TYPES.MOM.wordCount +=
```

```
tokenizer.countTokens();
                            break;
                        }
                        case CHILD: {
                            SPEAKER_TYPES.CHILD.wordCount +=
tokenizer.countTokens();
                            break;
                        }
                        case MOM_TO_CHILD: {
                            SPEAKER_TYPES.MOM_TO_CHILD.wordCount +=
tokenizer.countTokens();
                            break;
                        }
                        case DAD_TO_CHILD: {
                            SPEAKER_TYPES.DAD_TO_CHILD.wordCount +=
tokenizer.countTokens();
                            break;
                        }
                    }
                }
            }
        }
        File out = new File(fileName + "_out.txt");
        BufferedWriter writer = new BufferedWriter(new FileWriter(out));

        System.out.println("For file: " + fileName);
        writer.write("For file: " + fileName);
        writer.newLine();
        System.out.println("Total words per speaker:");
        writer.write("Total words per speaker:");
        writer.newLine();
        int total = 0;
        for (SPEAKER_TYPES type : SPEAKER_TYPES.values()) {
            if (type.countsForTotal()) {
                System.out.println(type + " : " + type.wordCount);
                writer.write(type + " : " + type.wordCount);
                writer.newLine();
                total += type.wordCount;
            }
        }
        System.out.println("Total words: " + total);
        writer.write("Total words: " + total);

        writer.newLine();
        String[] convos = speakerString.split("#");
        int convo_turns = 0;
        for (String convo : convos) {
            convo_turns += analyzeConvo(convo);
        }
        System.out.println("Conversation turns: " + convo_turns);
        writer.write("Conversation turns: " + convo_turns);
        writer.newLine();
        writer.flush();
        writer.close();
        System.out.println("Output file generated at: " +
out.getAbsolutePath());
    }

    private static int analyzeConvo(String convo) {
        int convoTurns = 0;
```

```
        // Found is a simple counter to show the three parts of a
conversation that we have found
        int found = 0;
        boolean startingChildOrAdult = false;
        String[] speakers = convo.split(":");
        for (String speaker1 : speakers) {
            SPEAKER_TYPES speaker = getSpeakerType(speaker1 + ":");
            // If this is our first attempt to find a conversation
            // This will not be true until we have found an adult or a child
            if (speaker != null) {
                if ((speaker.isAdult() || speaker.isChild()) && (found == 0))
{
                    startingChildOrAdult = speaker.isChild();
                    found = 1;
                } else if (found == 1) {
                    if (startingChildOrAdult) {
                        if (speaker.isAdult()) {
                            found = 2;
                        }
                    } else {
                        if (speaker.isChild()) {
                            found = 2;
                        }
                    }
                } else if (found == 2) {
                    if (startingChildOrAdult) {
                        if (speaker.isChild()) {
                            // We have a complete convo turn!
                            found = 1;
                            convoTurns++;
                        }
                    } else {
                        if (speaker.isAdult()) {
                            found = 1;
                            convoTurns++;
                        }
                    }
                }
            }
        }
        if (found == 2 && convoTurns > 0) {
            // We ended needing to find one more A or C to complete a convo,
add 1
            convoTurns++;
        }

        return convoTurns;
    }

    private static SPEAKER_TYPES getSpeakerType(String token) {
        if (token.equals(SPEAKER_TYPES.MOM.tag)) {
            return SPEAKER_TYPES.MOM;
        }
        if (token.equals(SPEAKER_TYPES.DAD.tag)) {
            return SPEAKER_TYPES.DAD;
        }
        if (token.equals(SPEAKER_TYPES.DAD_TO_CHILD.tag)) {
            return SPEAKER_TYPES.DAD_TO_CHILD;
        }
        if (token.equals(SPEAKER_TYPES.CHILD.tag)) {
```

```
            return SPEAKER_TYPES.CHILD;
        }
        if (token.equals(SPEAKER_TYPES.MOM_TO_CHILD.tag)) {

            return SPEAKER_TYPES.MOM_TO_CHILD;
        }
        // Else this is a regular old token
        else {
            return null;
        }
    }

    private static void parseInputs(String[] args) {
        for (int i = 0; i < args.length; i++) {
            if (args[i].equals("-file")) {
                try {
                    fileName = args[++i];
                } catch (ArrayIndexOutOfBoundsException e) {
                    System.err.println("Missing required parameter -file!");
                }
            }
        }
    }

    private static List<String> readFile(File file) {
        List<String> rtn = new ArrayList<String>();
        try {
            FileInputStream fstream = new FileInputStream(file);

            DataInputStream in = new DataInputStream(fstream);
            BufferedReader br = new BufferedReader(new
InputStreamReader(in));
            String line;
            while ((line = br.readLine()) != null) {
                if (!isLineIgnoreable(line)) {
                    rtn.add(line);
                }
            }
            in.close();
        } catch (IOException io) {
            System.err.println("File could not be opened at " +
file.getAbsolutePath());
        }
        return rtn;
    }


    private static boolean isLineIgnoreable(String line) {
        if (line.startsWith("[")) {
            return true;
        }
        if (timestamp.matcher(line).matches()) {
            return true;
        }
        // Still alive, we've survived!
        return false;
    }

    private enum SPEAKER_TYPES {
        MOM("MM:"), DAD("DD:"), CHILD("C:"), MOM_TO_CHILD("M:"),
```

```
DAD_TO_CHILD("D:"), CONVO_BREAK("#");

        protected String tag;
        protected int wordCount = 0;

        SPEAKER_TYPES(String tag) {
            this.tag = tag;
        }

        boolean isAdult() {
            return this.equals(MOM_TO_CHILD) || this.equals(DAD_TO_CHILD);
        }

        boolean isChild() {
            return this.equals(CHILD);
        }

        boolean countsForTotal() {
            return !(this.equals(CHILD) || this.equals(CONVO_BREAK));
        }

    }
}
```

Appendix B

Recordings, Overlaps, & Statistical Results

Table B1

Participant Recordings, LENA Outputs (Excluding Invalid Recordings)

Date	Adult Words (AW)	Conversational Turns (CT)	AW Percentile	CT Percentile
7/12/11	12862	430	67	51
7/14/11	5700	234	17	16
7/15/11	12252	454	26	20
7/20/11	3651	228	2	8
7/21/11	6118	356	10	25
7/23/11	6185	284	16	20
7/27/11	8578	285	29	18
7/29/11	6114	260	16	17
8/3/11	12335	250	33	7
8/27/11	7000	264	7	6
9/12/11	8598	218	26	8
9/14/11	7564	494	17	48
9/16/11	19221	838	80	82
10/1/11	17854	755	89	80
10/2/11	8409	438	4	20
11/2/11	5355	309	3	20
11/9/11	**13827**	**518**	**71**	**55**
11/11/11	8875	399	19	11
11/12/11	13961	407	26	16
11/19/11	**16347**	**613**	**82**	**62**
11/23/11	12062	602	34	50
11/23/11	**20849**	**973**	**95**	**90**
11/30/11	**16953**	**491**	**90**	**51**
12/18/11	11351	782	28	78
12/19/11	7750	536	25	69
1/7/12	6450	384	4	27
1/8/12	11312	484	44	48
1/11/12	6272	359	2	22
1/28/12	**16397**	**684**	**73**	**58**
2/1/12	13095	630	52	58
2/25/12	19507	815	73	63
Baseline Means	8080	22	313	20
Post Intervention Means	12939	47	580	51

Selected Baseline Means	8081	22	356	28
Selected Post Intervention Means	18861	81	803	75

Note: Baseline is in white, Post-Intervention is shaded. Recordings in boldface were omitted from this study due to speech therapy.

Note: Baseline recordings selected for transcriptions are outlined in black (912/11 and 9/14/11). Post-Intervention recordings selected for transcription are shaded in dark gray (9/16/11. 10/1/11, and 2/25/12).

Table B2

Mean Overlaps of Facilitative/Non-Facilitative Utterances Between Categories

Questions		Starts of Interactions		Feedback		Number of Utterances with Indicated Overlap	
Facilitative	Non Facilitative	Facilitative	Non Facilitative	Facilitative	Non Facilitative	Baseline	Post Intervention
x		x				*13*	**14**
x			x			*4*	**3**
x				x		*12*	**8**
x					x	*4*	**6**
	x	x				*3*	**7**
	x		x			*3*	**1**
	x			x		*3*	**1**
	x				x	*8*	**6**
		x		x		*2*	**2**
		x			x	*1*	**1**
			x	x		*2*	**4**
			x		x	*69*	**59**
x		x		x		*0*	**1**
x			x	x		*1*	**0**
x			x		x	*1*	**2**
x		x			x	*1*	**0**
	x	x		x		*1*	**0**
	x		x	x		*0*	**0**
	x		x		x	*1*	**0**
	x	x			x	*0*	**0**

Note: Total number of utterance overlaps removed from the final count of all facilitative utterances was 56 for baseline and 24 for post-intervention. Post-intervention overlaps are significantly lower than baseline due to the fewer number of negative feedback utterances, which often overlap with non facilitative responses.

Table B3

Mean Proportions of Utterances By Type and Chi-Square Statistical Significance of Quality/Facilitative Variable Means

Variable		Baseline	Post Intervention	Percent Improvement
Questions		213	240	--
	%CDU	21.0%	22.2%	--
WH		**164**	**179**	**8.9%**
	%Ques	77.0%	74.3%	-3.4%
	%CDU	16.1%	16.5%	*2.0%*
Facilitative		**52**	**59**	**14.6%**
	%WH	31.4%	33.0%	5.2%
	%Ques	24.2%	24.5%	1.5%
	%CDU	5.1%	5.4%	7.3%
Non Facilitative		113	120	--
	% WH	68.6%	67.0%	--
	%Ques	52.8%	49.8%	--
	%CDU	11.1%	11.0%	--
Yes/No		49	62	--
	%Ques	23.0%	25.7%	--
	%CDU	4.8%	5.7%	--
Facilitative		**18**	**23**	**27.8%**
	%Y/N	36.7%	37.3%	1.5%

	%Ques	8.5%	9.6%	13.2%	
	%CDU	1.8%	2.1%	*19.7%*	
Non Facilitative		31	39		
	%Y/N	63.3%	62.7%	--	
	%Ques	14.6%	16.1%	--	
	%CDU	3.1%	3.6%	--	
All Facilitative Questions		**70**	**82**	**18.0%**	
	%Ques	32.6%	34.1%	4.6%	
	%CDU	6.8%	7.6%	*10.5%*	
Starts of Interactions		227	221	--	
	%CDU	22.3%	20.4%	--	
Initiations		86	103	--	
	%Starts	37.7%	46.4%	--	
	%CDU	8.4%	9.5%	--	
Facilitative		**24**	**45**	**91.5%**	*
	%Initia	27.5%	43.8%	59.5%	**
	%Starts	10.4%	20.3%	96.4%	**
	%CDU	2.3%	4.1%	79.3%	
Non Facilitative		62	58	--	
	%Initia	72.5%	56.2%	--	
	%Starts	27.3%	26.1%	--	
	%CDU	6.1%	5.3%	--	
Responses		142	119	--	
	%Starts	62.3%	53.6%	--	
	%CDU	13.9%	10.9%	--	

Facilitative		**10**	**12**	**20.0%**	
	%Resp	7.1%	10.1%	43.1%	
	%Starts	4.4%	5.4%	23.1%	
	%CDU	1.0%	1.1%	*12.4%*	
Non Facilitative		132	107	--	
	%Resp	92.9%	89.9%	--	
	%Starts	57.9%	48.2%	--	
	%CDU	12.9%	9.8%	--	
All Facilitative Starts of Interactions		**34**	**57**	**70.1%**	**
	%Starts	14.8%	25.8%	74.5%	**
	%CDU	3.3%	5.3%	*59.3%*	
Feedback		411	340	--	
	%CDU	40.5%	31.3%	--	
Positive		**65**	**80**	**24.5%**	**
	%Feed	15.7%	23.7%	50.7%	**
	%CDU	6.3%	7.4%	*16.6%*	
Facilitative		**47**	**56**	**20.4%**	*
	%Pos	72.1%	69.7%	-3.3%	
	%Feed	11.3%	16.5%	45.7%	
	%CDU	4.6%	5.2%	12.8%	
Non Facilitative		18	23	--	
	%Pos	27.9%	28.2%	--	
	%Feed	4.4%	6.7%	--	
	%CDU	1.8%	2.1%	--	
Negative		347	259	25.2%	

%Feed	84.3%	76.3%	9.4%	**
%CDU	34.1%	23.9%	29.9%	**
All Facilitative Feedback	**47**	**56**	**20.4%**	**
%Feed	11.3%	16.5%	45.7%	**
%CDU	4.6%	5.2%	12.8%	
Total Categorized Utterances	733	691		
%CDU	72.1%	63.7%		
Total Facilitative Utterances	**124**	**171**	**38.7%**	*
%CDU	12.2%	15.8%	29.9%	**
Total Non Facilitative Utterances	624	539	13.5%	
%CDU	*61.4%*	*49.7%*	19.0%	
Total Uncategorized Utterances	*283*	*394*		
%CDU	*27.9%*	*36.3%*		
Total Child-Directed Utterances	*1016*	*1085*		

*Note: Variables where p < .05 are indicated by one *. Variables where p < .01 are indicated by two **. All numbers and totals are excluding any overlaps. Chi-square are statistics run on raw numbers of data are in boldface; z test statistics are run on proportions, not in boldface. Each row of percents is indicated by the %xx notation in the variables column. For example, under Facilitative WH Questions, %WH represents the percent of the recorded facilitative WH questions out of all WH questions; %Ques represents the percent of the recorded facilitative WH questions out of all questions, and %CDU represents the percent of the recorded facilitative WH questions out of all child-directed utterances.*